AD-A151 362 VAPOR EXPLOSIONS IN SUPERHEATED LIQUIDS AND FUNDAMENTAL STUDIES OF THE PH.. (U) WASHINGTON STATE UNIV PULLMAN DEPT OF PHYSICS G R FOWLES JAN 85 ARO-18200.4-CH 1/1

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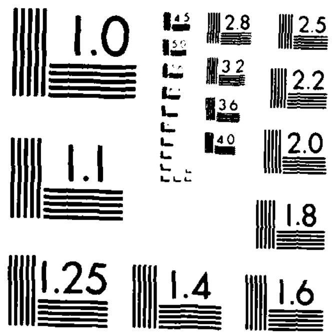

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20. ABSTRACT (Continue on reverse side if necessary and identify by block number)

The experimental work was entirely devoted to developing the experimental technique. In this technique superheated states are produced by sudden adiabatic depressurization of fluids whose initial state lies on the liquid-vapor co-existence curve, as is done on a more modest scale in bubble chambers. The technique is still being perfected and although it appears to be feasible and nearly functional, no data have yet been taken. Significant degrees of superheat have been obtained for several milliseconds. The theoretical phase, on shock and detonation instabilities, appears to have successfully shown

20. ABSTRACT CONTINUED:

the connection between transverse wave instabilities and the observed three-dimensional structure of detonation waves. It indicates that such transverse wave structure might be expected in all detonation waves and that it is caused by a modified form of the transverse wave instability predicted for shocks in inert materials.

ARO 18200.4-CH

FINAL TECHNICAL REPORT

Vapor Explosions in Superheated Liquids
and
Fundamental Studies of the Physics of Detonation

Department of Physics
Washington State University

Sept. 1, 1981 - Nov. 30, 1984

Contract DAAG29-81-K-0085
Army Research Office

PI: G. R. Fowles

January 1985

I. STATEMENT OF PROBLEM

This research program was initially titled "Vapor Explosions in Superheated Liquids." It was later modified to "Fundamental Studies of the Physics of Detonation" to encompass not only the original scope but also some related theoretical work on the structure and stability of shock and detonation waves.

The experimental phase, on superheated liquids, was undertaken to obtain quantitative, time-resolved measurements on wave propagation in fluids in metastable, superheated states. One goal of this research was to test a theory of vapor explosions based on detonation theory proposed by me earlier.[1-3] Related goals were to obtain data on the equation of state in the metastable regime, and to determine initiation and reaction rate information.

The theoretical phase of the work was aimed at clarifying the theory of instabilities of shock and detonation waves. In particular we wished to examine the connection, if any, between the transverse wave instabilities predicted theoretically and the transverse wave structure often observed in detonations. This work is a continuation of earlier research on shock wave instabilities.

II. SUMMARY OF RESULTS

The experimental work was entirely devoted to developing the experimental technique. In this technique we produce superheated states by sudden adiabatic depressurization of fluids whose initial state lies on the liquid-vapor co-existence curve, as is done on a more modest scale in bubble chambers. In the few milliseconds before nucleation and boiling can occur, we fire a pulsed laser, defocussed to a beam about 10 cm in diameter and directed onto a film of black plastic suspended in the fluid. The resulting pressure pulse caused by rapid heating of the plastic and surrounding fluid propagates as a plane wave in the fluid and its behavior is monitored with thin film pressure gauges. This technique is modelled after that developed by Migliori and Hofler.[4]

By measuring the velocity and amplitude of the pressure wave we expect to obtain information on the equation of state of the superheated fluid and to observe the interaction between the phase reaction and the wave propagation behavior, including the development of steady state detonation.

The technique is still being perfected and although it appears to be feasible and nearly functional, no data have yet been taken. Significant degrees of superheat have been obtained for several milliseconds, however. Mr. Flock is completing his Ph.D. thesis on this experiment and expects to finish in the next few months.

The theoretical phase, on shock and detonation instabilities, appears to have successfully shown the connection between transverse wave instabilities and the observed three-dimensional structure of detonation waves.[5] It indicates that such transverse wave structure might be

expected in all detonation waves and that it is caused by a modified form of the transverse wave instability predicted for shocks in inert materials. Moreover, the structure is not due to interactions of conventional Mach stems as is usually assumed but is instead due to interactions of waves closely related to Mach stems but otherwise not previously identified. They are supersonic, steady waves, whereas Mach stems are subsonic and unsteady (or quasi-steady).

Further work is necessary on the theory to fully understand the observed structure and to provide quantitative predictions for comparison with experimental data.

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4. A. Migliori and T. Hofler, (1) "Use of laser-generated acoustic pulses to measure the electric field inside a solid dielectric," Rev. Sci. Instr. 53, 662 (1982); (2) "Simple, reproducible, acoustically transparent pressure transducer with an 18 ns rise time," Rev. Sci. Instr. 52, 1865 (1981).

III. LIST OF PUBLICATIONS RESULTING FROM THIS CONTRACT

1. G. R. Fowles, "Shock Wave Stability," in Shock Waves in Condensed Matter, W. J. Nellis, L. Seaman, and R. A. Graham, eds. AIP Conference Proceedings No. 78 (1981), p. 520.

2. G. R. Fowles and A. F. P. Houwing, "Instabilities of shock and detonation waves," Phys. Fluids 27, 1982 (1984).

3. A. F. P. Houwing, G. R. Fowles, and R. J. Sandeman, "Shock wave instability and spontaneous acoustic emission for arbitrary disturbances in real gases," in Shock Tubes and Waves, proceedings of the 14th International Symposium on Shock Tubes and Waves, R. D. Archer and B. E. Milton, eds. (1983), p. 277.

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5. R. A. Flock and G. R. Fowles, "Vapor Explosions in Freon 22," Bull. Am. Phys. Soc. 27, 1179 (1982).

IV. PERSONNEL

G. R. Fowles, Professor of Physics, was the principal investigator, and Robert Flock was the research assistant. Mr. Flock expects to obtain the Ph.D. degree in June of 1985 based partly on his work on this contract. Some of the theoretical work was done by Fowles while he was on leave at the Australian National University, Canberra, Australia, in collaboration with A. F. P. Houwing of that university.

Another graduate student, Mark Thompson, also participated in the experiments.

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